Space Weather Technical Forecast

Issued on Tuesday, 02 May 2023 at 01:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of R1/R2 throughout. Active electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with an impulsive M7.1 flare peaking at 01/1309 UTC, originating from AR3288 in the southwest quadrant. There are currently five numbered sunspot regions on the visible disc. The largest is AR3288 located in the southwest quadrant, which consists of a number of mature spots and a delta spot in the intermediate portion of the region. AR3293 has also been quite active, with frequent low to mid C-class flares observed in the past 24 hours, in addition to the aforementioned M7.1 flare from AR3288. Meanwhile, AR3289 just east of the north-centre disc is also of note, as a small but compact region, although this has seen its previous delta spot now fade. AR3293 emerging from around the northeast limb is also worth keeping an eye on as it continues to rotate onto the disc, with this region showing some magnetic complexity, although its currently difficult to confidently analyse due to its oblique angle. There is the potential for this region to develop a delta spot. The remaining sunspot regions on the disc are smaller and simple. There are a number of potentially eruptive filaments on the Earth-facing disc, however no new Earth-directed CMEs were observed.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by ACE and DSCOVR at L1 was broadly indicative of a waning fast wind influence from CH96/-. Solar wind speeds started the period at slightly elevated levels, around 470-500km/s, before an enhancement to 500-570km/s, which may potentially be associated with a coronal hole fast wind from the northwest quadrant. Solar winds currently remain at elevated levels, between 500-550km/s. The density has been below average throughout. The total IMF, Bt, was weak at 5nT with the north-south component Bz varying between +4 nT and -4 nT. The phi angle was mainly negative (towards the Sun), but switched to mostly positive (away from Sun) direction around 01/1000 UTC, probably due to a Solar Sector Boundary Crossing (SSBC). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, has been at background levels throughout. High energy electron flux (greater than 2MeV) as measured at GOES16, has been at mostly High levels, peaking at 8863 pfu at 01/1600 UTC. The 24-hour integrated fluence was at Active levels, with an increasing trend, with 4.68e8 integrate pfu recorded at 02/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected with a chance of further M-class flares.

Solar Wind / Geomagnetic Activity: There are several CMEs which are expected to largely miss Earth in the coming days, however some glancing influences cannot be ruled out. The most likely candidate CME to affect Earth left the Sun on the 29 Apr and is expected to pass by late on day 1 or early day 2 (02 or 03 May). Otherwise current fast wind conditions are expected to

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gradually ease, although some peripheral enhancement is also possible from CH98/- through day 1 (02 May). The next HSS is likely to be from CH99/+ which is located in the southeast, although this is just beyond this forecast period. Geomagnetic activity is expected to be Quiet to Unsettled, but with ongoing chance of Active intervals, mainly late day 1 (02 May) or early day 2 (03 May) and a slight chance of G1 Minor Storm intervals.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to persist at background levels, but with a very slight chance of rising in response to any notable flares. High energy (greater than 2MeV) electron flux is expected persist at mainly High levels, but with peak levels probably gradually declining. Any CME arrival has the potential to suppress flux levels, reducing confidence from the end of day 1 (02 May) onwards. The associated 24 hour Electron fluence is currently above the Active level (1e8 integrated pfu) and expected to persist at this level, albeit likely with a declining trend overall, with confidence decreasing by day 2 (03 May).

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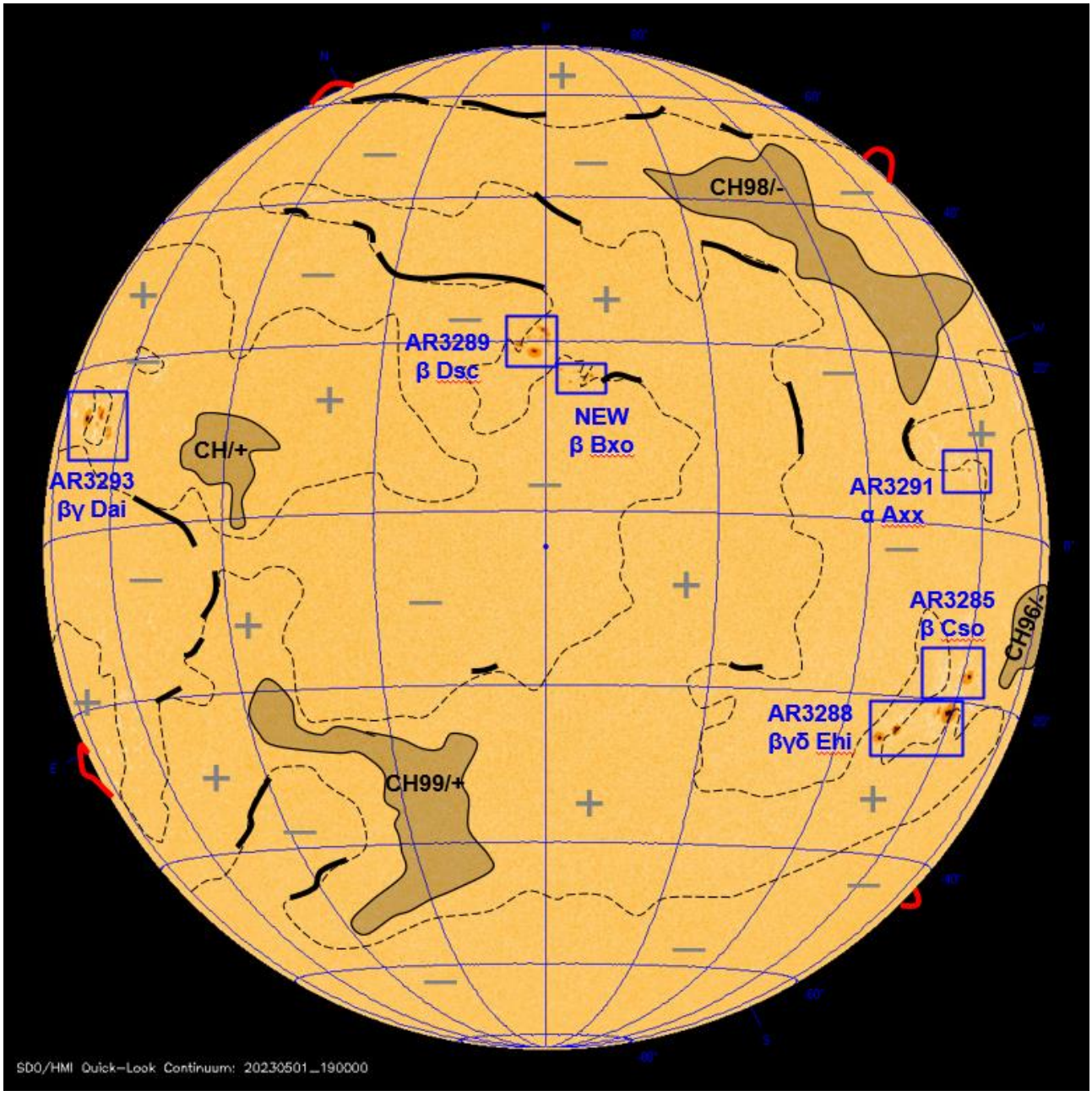
Figure 1. Solar Analysis Valid 01/1900 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There have been numerous mainly faint filament eruptions resulting in observable CMEs over the past few days. These have been assessed as largely missing Earth, however some glancing influences are possible on most days (02-04 May) due to their proximity as they pass Earth. The most likely of these to give any noticeable impact is from a CME which occurred early on 29 Apr from near AR3288. Any interaction from this is likely to be late on day 1 or early day 2 (02-03 May) as it passes mostly to the south of Earth.

Otherwise, the fast wind from CH96/- is expected to continue easing, with the current elevated to slightly elevated speeds declining erratically towards background speeds by the end of day 2 (02 May). This is only moderate confidence, however, as CH98/- in the northern disc may prolong the slightly elevated winds until day 2 (03 May), although any HSS from this feature is currently signalled by enlil to pass largely north of Earth. No other significant enhancements are expected.

Geomagnetic activity is expected to be mostly Quiet to Unsettled, but with ongoing chance of Active intervals from any CME influence, most likely late day 1 or into day 2 (02 or 03 May) and a slight chance of G1 Minor Storm intervals. Any influence from CH98/- HSS also brings the chance of isolated Active intervals on day 1 (02 May).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	15	10	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
29/1002	Partial	Filament Eruption	S disc near AR3288	510 km/s	02/2200 UTC +/- 12 hours	Chance of glancing impact late 02 or early

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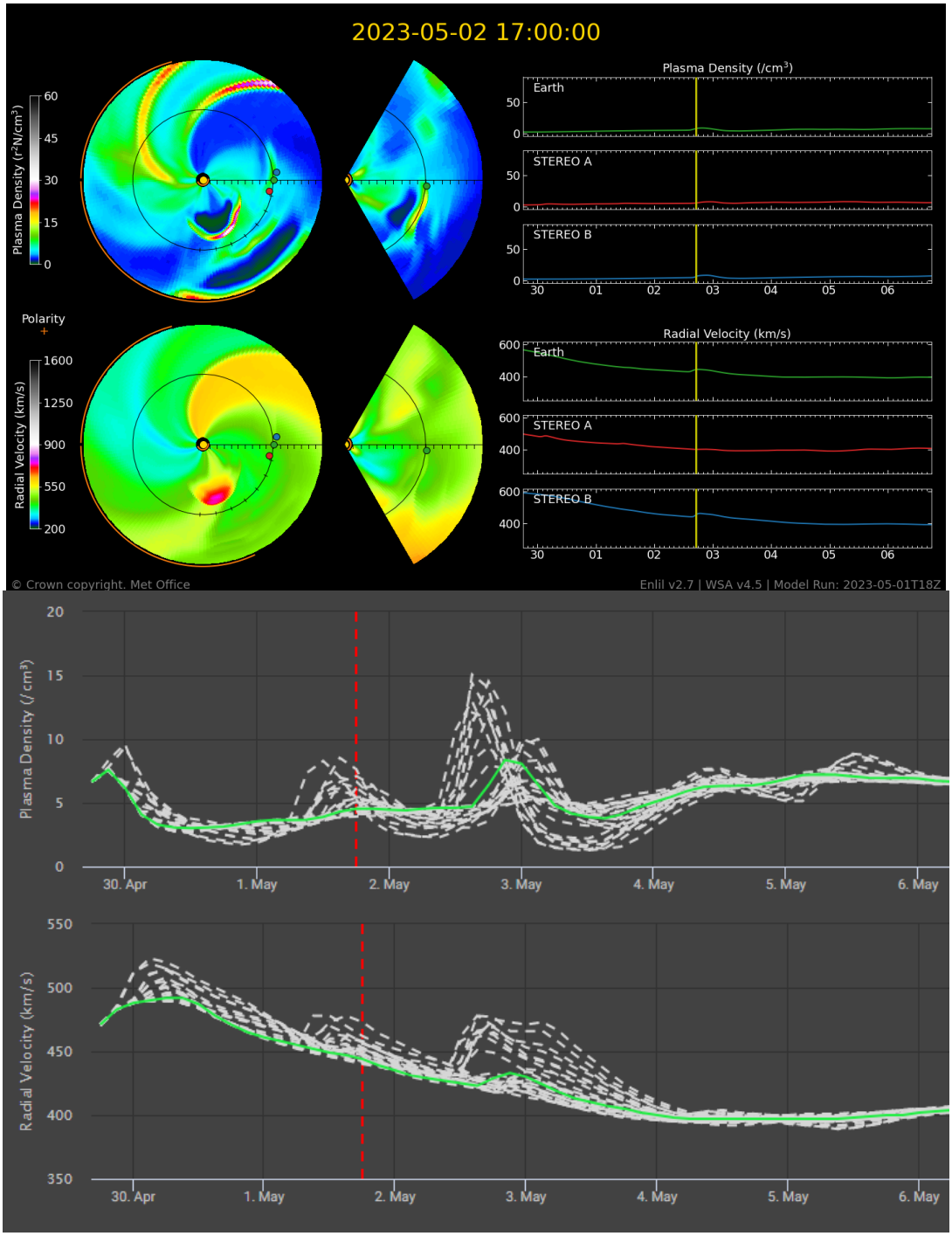
Figure 2: Latest Enlil (top) output showing possible arrival of CME late on 02 May. Ensemble plot (bottom) suggests a chance of other glancing CME arrivals during the coming days.



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Radio Blackouts - X-Ray Flares:
Moderate to Low activity is expected with an ongoing chance of M-flares (R1-R2 Radio Blackouts). Of the five sunspot regions on the disc, three of them are currently considered the most likely source regions of any notable flaring.

The first of these is AR3288 in the southwest. This is a wide region consisting of a number of spots with strong umbra and symmetric penumbra, including a clear, albeit small delta spot. This has also moved close to AR3285, a large but simple spot to its northwest that further complicates the magnetic looping of this region.

The second is AR3289, just east of the north-central disc, and is a compact and small region consisting of four separate penumbra areas each with small umbra. This did have a small delta spot, which it has now faded. A new and currently unnumbered sunspot region has emerged to the southwest of AR3289. This area will be monitored for any further development.

The third is the newly numbered region AR3293 that has emerged onto the disc from over the northeast limb. The region has been the source of an M-flare as well as frequent low-mid level C-class flares. This is currently difficult to analyse due to the viewing angle, although it can be seen to harbour some magnetic complexity and is classified as a Beta-Gamma configuration. This region will continue to be monitored for any further developments, with the potential for a 'delta' spot to emerge.

There is another sunspot emerging on the eastern limb horizon, which looks to be quite large, although difficult to ascertain at present due to foreshortening effect. This may be Ex-3280, which can be seen on the far-sided seismic monitor from Stanford and the bright flux region seen on EUVI/AIA 195 imagery.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	45	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

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Figure 3: GOES-16/18 X-ray flux – shows the recent M7.1 flare originating from AR3288 in the southwest.

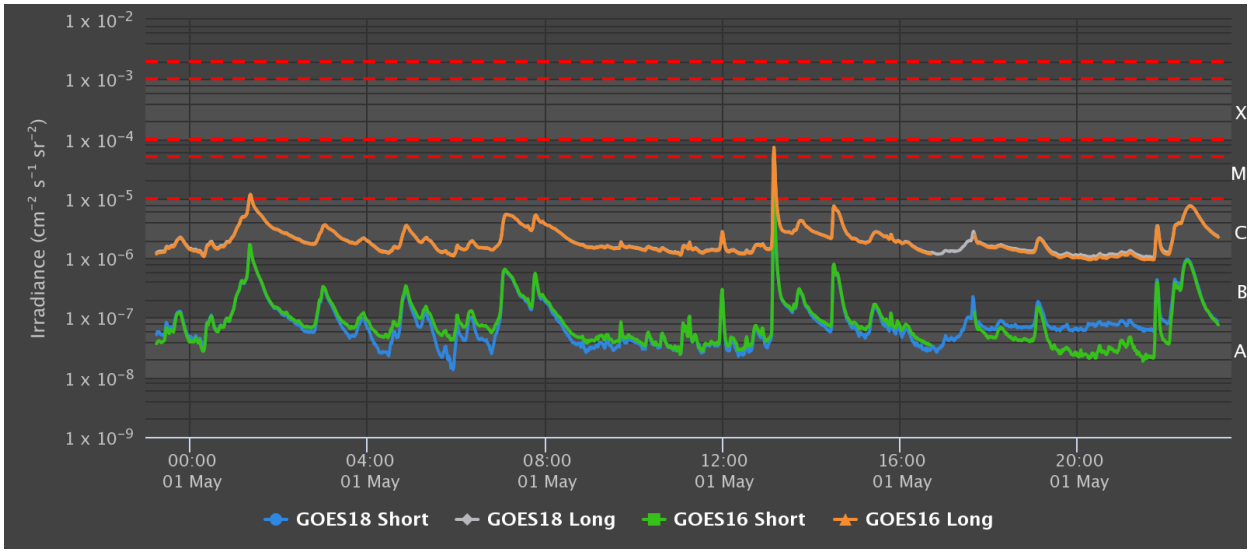
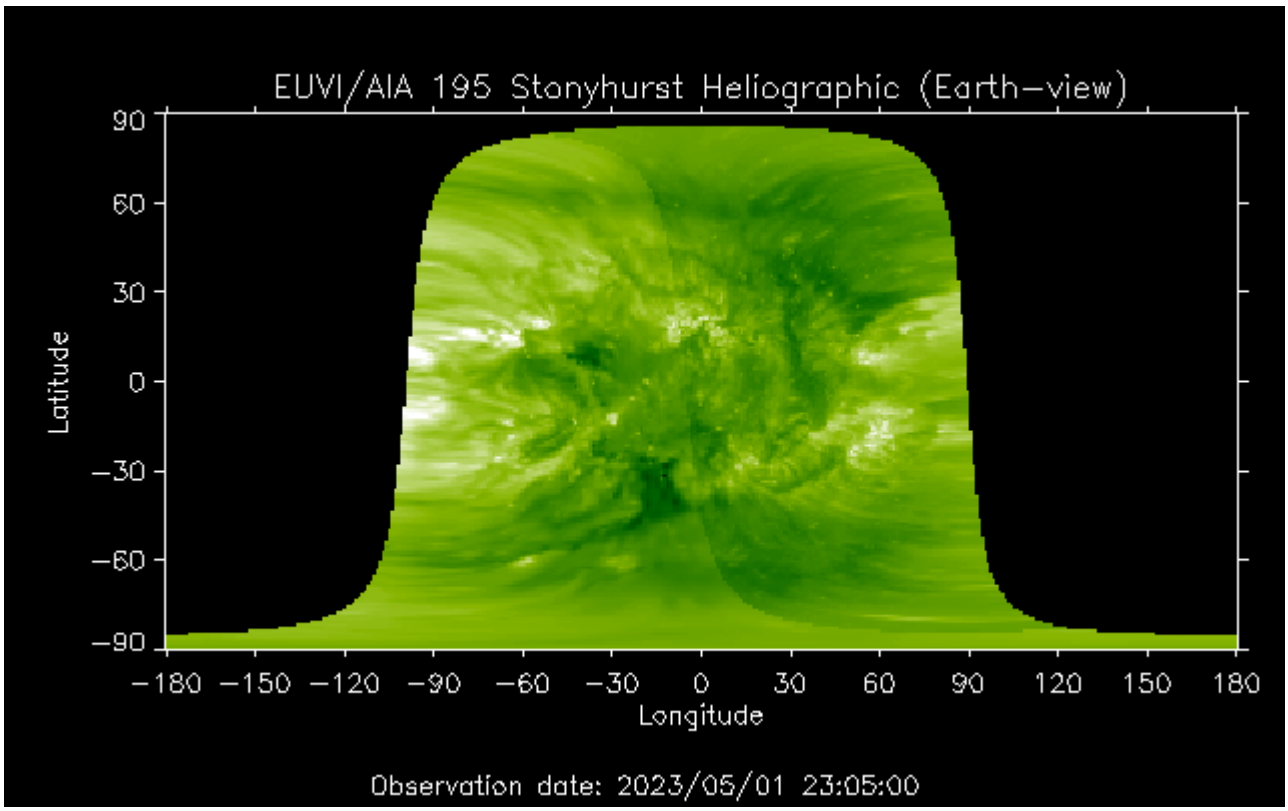


Figure 4: - EUVI/AIA 195 Stonyhurst Heliographic – shows bright flux regions near the east limb, which will rotate onto the visible disc in the coming days.



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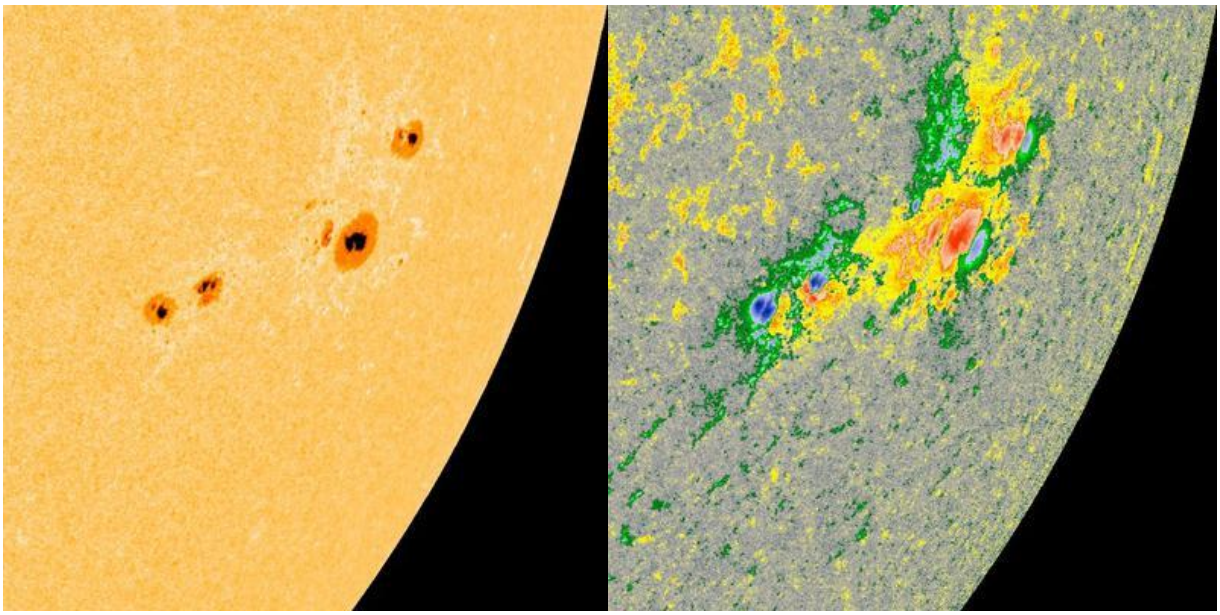
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux as observed by GOES-16 is forecast to remain at background, with no solar radiation storms expected. Any significant flares, primarily from AR3288 or AR3289, have the potential to increase the observed flux towards the S1 Minor radiation storm threshold, with a very slight chance of exceeding.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: SDO HMI-Intensitygram and Magnetogram of AR3288 and AR3285 in the southwest quadrant.



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High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2MeV) electron flux as observed by GOES-16 at GEO is expected to continue at mainly High levels through day 1 (02 May), albeit probably with an overall declining trend outside of diurnal influences. Confidence falls by the end of day 1 due to the chance of CME arrivals, which have the potential to suppress the observed flux if they occur. However, these are generally expected to miss Earth with mainly High levels continuing. By day 3 and 4 (04 and 05 May) more prolonged periods of Moderate to Background flux are likely, mainly during the diurnal minimum period, with peak flux gradually declining.

Electron fluence is currently above the Active (1e8 integrated pfu) threshold and is likely to stay that way through the period, but with an erratically decreasing trend. There is very slightly elevated probabilities of Very High fluence being reached on day 1 (02 May). Confidence reduces day 3 (04 May) onward, due to uncertainties about how quickly peak flux values will decay, along with the potential for any CME arrivals resulting in flux dropping out. REFM supports a declining trend, however this is currently considered likely too rapid with its decline.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	70	60	50
Very Active	≥ 2 MeV ≥ $1x10^9$	No	5	5	1	1

Figure 6: MOSWOC REFM Electron Fluence – observations and forecast.

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